Conference Paper

Use of Regeneration Products of Moulding Mixtures for Construction and Refractory Materials Manufacturing

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Abstract

Composition and regeneration properties of the molding sand mixtures worked out of casting production – quartz sand and dust fraction. The results of the laboratory investigations as to their use in both building and refractory materials composition are presented. The industrial tests have shown the high efficiency of silica rich regenerated products in dinas products manufacture.

Keywords: molding sand mixtures worked out, regeneration products, composition, properties, building materials, refractories

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1. Introduction

The development of non-waste technologies quaranting the high extent of valuable components extraction from technogenic waste and obtaining high quality products on the basis of the silicate passing products of metallurgy, heat power industry, machine building is a very actual problem. Molding sand mixtures (MSM) consisting of primarily quartz sand and binding components, namely: bentonite, water glass, resin etc. are widely used at machine building and metallurgical plants to produce moulds. Depending on the product mass the MSM consumption is in the range of 5 to 13 t/t of the finished castings. Having produced the castings the mould is broken and MSM are transported to dump, where they are stored polluting the surrounding environment. At present tens of thousand million tons of the burnt soil have been accumulated only at the machine building plants dumps.

MSM contain 90-95 % of SiO_2, up to 6 % of Al_2O_3, up to 1.5 % of CaO+MgO, 0.7-1.5 % of Fe_2O_3 and consist of in general quartz sand, scale mixtures and binding materials residues used to sand moulds. One of the most possible MSM utilization ways is regeneration which is that sand is taken from them, i.e. the moulds to be reused [1]. The mechanical way of regeneration involves crushing of the moulds, magnetic separation of metallic inclusions screening with simultaneous sand dedusting and binder removal. As this takes place the fine fraction proper is not used and goes to dump. At the

same time according to the specialists evaluation the MSM regeneration products can be used as silica correcting component of the Portland cement raw mixture, mineral addition when cement grinding, fine aggregate for concrete production and also as a binding content in the artificial ground mixtures and asphalt concrete taking into account their chemical, grain composition and ceramic products [2–7].

2. Results and Discussion

When using clays with low SiO_2 content in the raw mixture of Portland clinker raw mixture it is recommended to apply the correcting silica addition consisting of 80-95 % of SiO_2 to increase silicate modulus. As a rule such rocks as tripoli, diatomite, marshalite, quartz sand including technogenic waste and the passing products e.g. burnt grounds consisting in general of quartz are introduced at cement plants. So, at AO Nevyansk Cementnik MSM formed at Uralmash and Ural chemical works etc. were used for many years in cement clinker raw mixture obtained by dry method. The burnt ground consumption was in the range of 2.5-3 % of the raw meal weight or 40-50 kg/t of clinker.

Another way of MSM utilization can be their use as a mineral addition when portland cement grinding. However, the burnt grounds are characterized with changeable chemical and phase composition and different hydraulic activity which depends on the binder type used in MSM content. It is established that MSM in which clay and water glass were used as a binder possess the highest activity and the least one-with the resin binders hardened with phosphoric acid [2]. The optimum MSM additive quantity to cement is 10 %, but when 20 % is added the compressive strength is reduced by 8-10 % (by 4-5 MPa).

As a rule coarse quartz sand is used to produce sand asphalt concrete, its share being up to 80-85 % of the total concrete volume. Sand materially increases homogeneity and placeability of asphalt concrete mixture attributing to more favourable concrete structure formation on densification. The investigations proper have shown that the 25 % of quartz sand replacement with MSM increases compressive strength, reduces volume swelling and asphalt concrete absorbtion. Besides MSM can be used to arrange the drainage layers in road building. The burnt ground is to have the filtration coefficient more than 3 m daily, to consist of more than 3 % of clay, dust and other fine particles. Special mixtures consisting of up to 1300 kg/m^3 of MSM have been matched on the basis of bitumen and portland cement composition to build foundations under side-roads and automobile roads.

The investigation results as to the MSM of the casting production at AO Sucholozh cast-mechanical plant application in the technology of some construction materials

Material	Humidity, %	Bulk density, kg/m^3	Apparent density, g/cm^3	Grain content, weight %, mm in size			
				1,25-0,63	0,63-0,315	0,315-0,16	>0,16
Sand	0.03	1140	2.63	1.0	37.1	56.8	5.1
Fine fraction	0.30	920	2.58	-	2.6	25.2	72.2

Table 1: Physical properties of the molding sand mixtures regenerated products.

Material	LOI, weight %	Oxides content, weight %					Quartz content, %
		SiO_2	Al_2O_3	Fe_2O_3	CaO	Other	
Sand	0.93	98.00	0.64	0.23	0.04	0.16	94.3
Fine fraction	2.35	95.04	1.22	1.07	0.11	0.21	88.5

Table 2: Chemical composition of mold mixture regeneration products.

and refractories are given in the present work. The mechanical regeneration method of MSM had been used including crushing, mechanical separation, grinding and partition (separation) of the product into sand and fine fraction. Thus, the secondary quartz sand obtained in the quantity not less than 50 % from the total mass of the burnt clay further was used in the MSM content.

The properties and composition of MSM regeneration products are given in Tables 1 and 2. The fine fraction is characterized mainly with the particles not less than 0.16 mm in size and specific surface is equal to 163 m^2/kg (which was determined by the air permeability). The chemical composition of MSM is characterized in general by SiO_2, however, the increased quantity of $A1_2O_3$ and Fe_2O_3 is available in it, that is in the fine fraction. The quartz content proper both in sand and the fine fraction obtained from MSM is 94.3 % and 88.5 % accordingly.

№	Components content, kg/m^3				Mortar density, kg/m^3	Compressive strength limit, MPa
	Portland cement	Natural sand	MSM fine fraction	Water		
1	336	1510	-	324	2013	7.1
2	304	1520	34	317	2010	6.2
3	270	1520	68	307	2008	5.5
4	333	1050	450	316	2018	7.6

Table 3: Influence of moulding mixture fine fraction on the masonry mortar properties.

№	Components of composition, kg/m^3					Density, kg/m^3	Compressive strength limit, MPa		Strength class
	Portland cement	Broken stone	Screenings sand of	MSM fine fraction	Water		After steam curing	Normal hardening	
1	234	1074	822	-	250	2220	6.15	42.9	B12.5
2	241	1094	749	83 (10 %)	216	2215	7.50	49.2	B10
3	246	1100	659	165 (20 %)	210	2225	5.10	26.7	B15
4	248	1100	570	244 (30 %)	208	2230	6.60	38.4	B15

Table 4: Composition and properties of concrete with fine fraction of molding mixture.

№	Components of composition, kg/m^3					Density, kg/m^3	Strenth limit after steam curing, MPa	
	Portland cement	Natural sand	Screenings sand	Regenerated sand	Water		Bend	Compression
1	547	1640	-	-	271	2350	6.15	42.9
2	532	-	1595	-	266	2290	7.50	49.2
3	482	-	-	1447	269	2080	5.10	26.7
4	517	-	776	776	267	2225	6.60	38.4

Table 5: Influence of sand type on the composition and properties of fine grained concrete.

In order to widen the utilization of MSM regeneration products direction in heavy and fine grained concrete composition, torcrete mortars, refractory products the possibility of their utilization has been studied. The most favourable results and effective directions as to the burnt ground utilization are considered below.

Concrete mixture is known to consist of sand as fine aggregate of crushed granite screenings, when mobility is satisfactory it is characterized with high water consumption. Screenings replacement by 10-30 % of MSM fine fraction reduces water consumption by 15-20 % under the workability planned (Table 3), which seems to be connected with particles of round shape and plasticizers of the organic substances attack present in it, which were used in the mold masses composition. The fine regeneration MSM product addition increases by 22-26 % the concrete strength both before curing and hardening in moisture conditions in 28 days (by 26-31 %) and in the quantity of screenings mass (165-244 kg/m^3) quarantes its B15 class strength.

The possibility of the sand application obtained by means of MSM regeneration in the fine grained concrete composition intended for wall stones or pavement tile use has been investigated. It has been established that concrete mixtures with both natural sand and screenings one have close water cement ratio. The application of the regenerated sand increases by 12-13 % water consumption and considerably reduces (by 9-12 %) concrete mixture density (Table 4). Replacement of 50 % sand from screenings by regenerated sand slightly increases water consumption and decreases

mixture density. It has been found that the sand type influences the fine grained concrete strength. Concrete made of the crushed screenings sand possesses the highest bending and compressive strength, but when the regenerated sand is introduced into concrete the strength of the latter decreases. Thus, MSM regenerated sand is not recommended for use as an aggregate in the fine grained concrete composition.

Also the possibility to use MSM fine fraction in the building mortar content has been considered. It is shown that its addition reduces water consumption of the mortar masonry mixture when concrete mobility is the same $P_k 2$ and practically fails to affect the masonry mortar density which is heavy (density more than 1500 kg/m^3) (Table 3). Both 10 % and 20 % concrete replacement with MSM fine fraction decreases the strength limit when masonry mortar of normal hardening is compressed by 14-29 %, but 30 % of its introduction instead of the natural sand increases strength by 9 % and guaranties its M75 strength grade.

Dinas refractories are produced by using quartz sand as one of the raw materials components. Taking into account high quartz content the possibility to use MSM regeneration producs in dinas products charge instead of the natural sand has been considered. On the basis of the laboratory investigations the optimal quantity of sand and fine fraction from MSM has been determined guaranting the normative indicators of the refractories in question. Commercial experiments have shown that the product yield from the experimental charge and physico-mechanical properties of the experimental dinas correspond to the refractory quality level produced in accordance with traditional technology [8].

3. Summary

Thus, the science-technical literature analysis, laboratory works and commercial experiments have shown that mold mixtures completed their term of service and their regenerated products expediently to use in both portland cement production and dinas refractories, in the asphalt concrete composition, cement heavy concretes and building mortars in particular.

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